Developments in Language Theory

11th International Conference, DLT 2007
Turku, Finland, July 3-6, 2007
Proceedings
Preface

The 11th International Conference on Developments in Language Theory (DLT 2007) was held at the University of Turku, Finland, July 3–6, 2007. This was the second time DLT took place in Turku. Indeed, the very first meeting was organized in Turku in 1993. Consequent meetings were held in Magdeburg (1995), Thessaloniki (1997), Aachen (1999), Vienna (2001), Kyoto (2002), Szeged (2003), Auckland (2004), Palermo (2005), and Santa Barbara (2006). The conference series is held under the auspices of the European Association for Theoretical Computer Science.

The DLT meeting can be viewed as the main conference on automata and formal language theory. The current topics of the conference include the following: grammars, acceptors and transducers for strings, trees, graphs and arrays, efficient text algorithms, algebraic theories for automata and languages, combinatorial and algebraic properties of words and languages, variable-length codes, symbolic dynamics, decision problems, relations to complexity theory and logic, picture description and analysis, polyominoes and bidimensional patterns, cryptography, concurrency, bio-inspired computing, quantum computing. This volume of Lecture Notes in Computer Science contains the papers that were presented at DLT 2007, including the abstracts or full papers of the six invited speakers Volker Diekert (Stuttgart), Thomas Henzinger (Lausanne), Michal Kunc (Brno), Ming Li (Waterloo), Jacques Sakarovitch (Paris), and Kai Salomaa (Kingston).

For the conference, 32 contributed papers were selected from a record-breaking 74 submissions. We warmly thank the authors of the papers, the members of the Program Committee, who faced many hard decisions, and the reviewers of the submitted papers for their valuable work. All these efforts were the basis of the success of the conference. In particular, we are very thankful to the invited speakers of the conference. Finally, we thank the Organizing Committee for its splendid work and also the members of the Steering Committee.

Finally, we wish to thank the support of the conference sponsors: The Academy of Finland, The Finnish Cultural Foundation, the Finnish Academy of Science and Letters / Vilho, Yrjö and Kalle Väisälä Foundation, the City of Turku, the University of Turku, the Turku Centre for Computer Science, and Centro Hotel.

April 2007

Tero Harju
Juhani Karhumäki
Arto Lepistö
DLT 2007 was organized by the Department of Mathematics and Centre for Fundamentals of Computing and Discrete Mathematics (FUNDIM), University of Turku.

**Invited Speakers**

Volker Diekert (Stuttgart, Germany)
Thomas Henzinger (Lausanne, Switzerland)
Michal Kunc (Brno, Czech Republic)
Ming Li (Waterloo, Canada)
Jacques Sakarovitch (Paris, France)
Kai Salomaa (Kingston, Canada)

**Program Committee**

Cristian Calude (Auckland, New Zealand)
Julien Cassaigne (Marseille, France)
Christian Choffrut (Paris, France)
Jürgen Dassow (Magdeburg, Germany)
Bruno Durand (Marseille, France)
Massimiliano Goldwurm (Milan, Italy)
Tero Harju, Co-chair (Turku, Finland)
Juraj Hromkovič (Zurich, Switzerland)
Oscar Ibarra (Santa Barbara, USA)
Lucian Ilie (London, Canada)
Masami Ito (Kyoto, Japan)
Nataša Jonoska (Tampa Bay, USA)
Juhani Karhumäki, Co-chair (Turku, Finland)
Wojciech Rytter (Warsaw, Poland)
Mikhail Volkov (Ekaterinburg, Russia)
Klaus Wagner (Würzburg, Germany)

**Organizing Committee**

Juhani Karhumäki (Co-chair)
Vesa Halava (Co-chair)
Elena Czeizler
Eugen Czeizler
Eero Lehtonen
Arto Lepistö
Alexander Okhotin
Petri Salmela
Referees

F. Ablayev    I. Honkala    F. Otto
R. Alur       J. Honkala    B. Palano
A. Angeleska  J. Hromković  G. Paun
M. Babenko    O. Ibarra     D. Perrin
A. Ballier    L. Ilie       G. Pighizzini
L. Bienvenu   M. Ito        J.-E. Pin
H.-J. Böckenhauer E. Jeandel J. Pirnot
P. Boldi      N. Jonoska    W. Plandowski
L. Breveglieri J. Justin     R. Radicioni
H. Buhrman    C. Kapoutsis  B. Ravikumar
C. Calude     J. Karhumäki  C. Reutenauer
O. Carton     J. Kari       G. Richomme
J. Cassaigne  L. Kari       A.E. Romashchenko
A. Cherubini  D. Kephart    W. Rytter
C. Choffrut   R. Kralovic   K. Saari
M. Chrobak    D. Krob       P. Salmela
B. Courcelle  M. Kutrib     A. Salomaa
M. Crochemore S. Lasota     K. Salomaa
F. D’Alessandro M. Latteux   N. Santean
J. Dassow     A. Lepistö     M. Santha
F. Drewes     F. Levé        S. Seibert
E. Duchi      G. Lischke    V. Selivanov
B. Durand     K. Lodya       A. Shen
Z. Fülöp      M. Lohrey     A. Staninska
E. Formenti   S. Lombardy   J.-M. Talbot
A. Frid       V. Lonati     D. Tamascelli
P. Gastin     P. Madhusudan  N. Tran
M. Goldwurm   P. Massazza    S. Travers
P. Goralčík  B. Masson     R. Treinen
J. Gruska     C. Mereghetti  G. Vaszl
Y. Guesnet    T. Momke      M. Volkov
V. Halava     B. Nagy       K. Wagner
T. Harju      E. Ochmański  H.-C. Yen
M. Hirvensalo A. Okhotin    S. Yu
M. Holzer     N. Ollinger   

Sponsoring Institutions

The Academy of Finland
The Finnish Cultural Foundation
Finnish Academy of Science and Letters / Vilho, Yrj and Kalle Visl Fund
Nokia Foundation
Turku University Foundation
Centro Hotel
# Table of Contents

## I Invited Talks

On First-Order Fragments for Words and Mazurkiewicz Traces  
*Volker Diekert and Manfred Kufleitner*  
1

Quantitative Generalizations of Languages  
*Thomas A. Henzinger*  
20

What Do We Know About Language Equations?  
*Míchal Kunc*  
23

Information Distance and Applications  
*Míng Li*  
28

Finite Automata and the Writing of Numbers  
*Jacques Sakarovitch*  
29

Descriptive Complexity of Nondeterministic Finite Automata  
*Kai Salomaa*  
31

## II Contributed Papers

From Determinism to Non-determinism in Recognizable Two-dimensional Languages  
*Marcella Anselmo, Dora Giammarresi, and Maria Madonia*  
36

Coding Partitions: Regularity, Maximality and Global Ambiguity  
*Marie-Pierre Béal, Fabio Burderi, and Antonio Restivo*  
48

Multi-letter Reversible and Quantum Finite Automata  
*Aleksandrs Belovs, Ansis Rosmanis, and Juris Smotrovs*  
60

Approximability and Non-approximability Results in Computing the Mean Speedup of Trace Monoids  
*Alberto Bertoni and Roberto Radicioni*  
72

The Dynamics of Cellular Automata in Shift-Invariant Topologies  
*Laurent Bienvenu and Mathieu Sablik*  
84

Two Element Unavoidable Sets of Partial Words  
*Francine Blanchet-Sadri, Naomi C. Brownstein, and Justin Palumbo*  
96
Hairpin Finite Automata................................................................. 108  
  *Henning Bordihn, Markus Holzer, and Martin Kutrib*

Characterizing Reduction Graphs for Gene Assembly in Ciliates .... 120  
  *Robert Brijder and Hendrik Jan Hoogeboom*

2-Visibly Pushdown Automata.................................................... 132  
  *Dario Carotenuto, Aniello Murano, and Adriano Peron*

An Efficient Computation of the Equation $K$-Automaton of a Regular $K$-Expression ................................................................. 145  
  *Jean-Marc Champarnaud, Faissal Ouardi, and Djelloul Ziadi*

An Extension of Newton’s Method to $\omega$-Continuous Semirings .... 157  
  *Javier Esparza, Stefan Kiefer, and Michael Luttenberger*

Non-constructive Methods for Finite Probabilistic Automata .......... 169  
  *Rūsiņš Freivalds*

The Unambiguity of Segmented Morphisms ................................ 181  
  *Dominik D. Freydenberger and Daniel Reidenbach*

Commutation of Binary Factorial Languages ................................ 193  
  *Anna E. Frid*

Inapproximability of Nondeterministic State and Transition Complexity Assuming $P \neq NP$ ............................................................................. 205  
  *Hermann Gruber and Markus Holzer*

State Complexity of Union and Intersection of Finite Languages .... 217  
  *Yo-Sub Han and Kai Salomaa*

Bisimulation Minimisation for Weighted Tree Automata ................. 229  
  *Johanna Högberg, Andreas Maletti, and Jonathan May*

Conjunctive Grammars Can Generate Non-regular Unary Languages  242  
  *Artur Jeż*

Deterministic Blow-Ups of Minimal Nondeterministic Finite Automata over a Fixed Alphabet ............................................................ 254  
  *Jozef Jirásek, Galina Jirásková, and Alexander Szabari*

Reduced Languages as $\omega$-Generators ...................................... 266  
  *Sandrine Julia and Tran Vinh Duc*

Avoiding Approximate Squares .................................................... 278  
  *Dalia Krieger, Pascal Ochem, Narad Rampersad, and Jeffrey Shallit*

Duplication Roots ........................................................................... 290  
  *Peter Leupold*
<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complexity Theory for Splicing Systems</td>
<td>300</td>
</tr>
<tr>
<td><em>Remco Loos and Mitsunori Ogihara</em></td>
<td></td>
</tr>
<tr>
<td>Descriptional Complexity of Bounded Context-Free Languages</td>
<td>312</td>
</tr>
<tr>
<td><em>Andreas Malcher and Giovanni Pighizzini</em></td>
<td></td>
</tr>
<tr>
<td>Definable Transductions and Weighted Logics for Texts</td>
<td>324</td>
</tr>
<tr>
<td><em>Christian Mathissen</em></td>
<td></td>
</tr>
<tr>
<td>A Star Operation for Star-Free Trace Languages</td>
<td>337</td>
</tr>
<tr>
<td><em>Edward Ochmański and Krystyna Stawikowska</em></td>
<td></td>
</tr>
<tr>
<td>Finite Automata on Unranked and Unordered DAGs</td>
<td>346</td>
</tr>
<tr>
<td><em>Lutz Priese</em></td>
<td></td>
</tr>
<tr>
<td>On Almost Periodicity Criteria for Morphic Sequences in Some</td>
<td>361</td>
</tr>
<tr>
<td>Particular Cases</td>
<td></td>
</tr>
<tr>
<td><em>Yuri Pritykin</em></td>
<td></td>
</tr>
<tr>
<td>A Local Balance Property of Episturmian Words</td>
<td>371</td>
</tr>
<tr>
<td><em>Gwénaël Richomme</em></td>
<td></td>
</tr>
<tr>
<td>Suffix Automata and Standard Sturmian Words</td>
<td>382</td>
</tr>
<tr>
<td><em>Marinella Sciortino and Luca Q. Zamboni</em></td>
<td></td>
</tr>
<tr>
<td>Fine Hierarchy of Regular Aperiodic $\omega$-Languages</td>
<td>399</td>
</tr>
<tr>
<td><em>Victor L. Selivanov</em></td>
<td></td>
</tr>
<tr>
<td>On Transition Minimality of Bideterministic Automata</td>
<td>411</td>
</tr>
<tr>
<td><em>Hellis Tamm</em></td>
<td></td>
</tr>
<tr>
<td><strong>Author Index</strong></td>
<td>423</td>
</tr>
</tbody>
</table>